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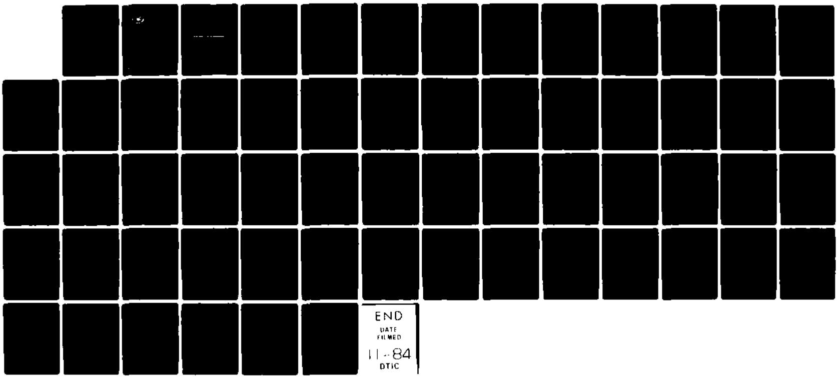

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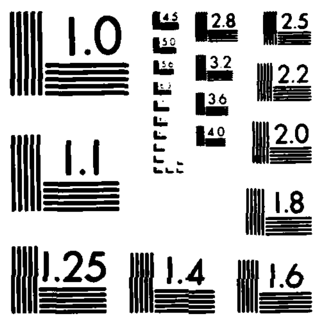

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CR 84.029

NAVAL CIVIL ENGINEERING LABORATORY
Port Hueneme, California

Sponsored by
NAVAL FACILITIES ENGINEERING COMMAND

AD-A146 443

USER'S MANUAL FOR THE HEAT RECOVERY INCINERATOR (HRI) MODEL

June 1984

An Investigation Conducted by:
L.I. DIMMICK CORPORATION
P.O. Box 2857
Oxnard, CA 93034

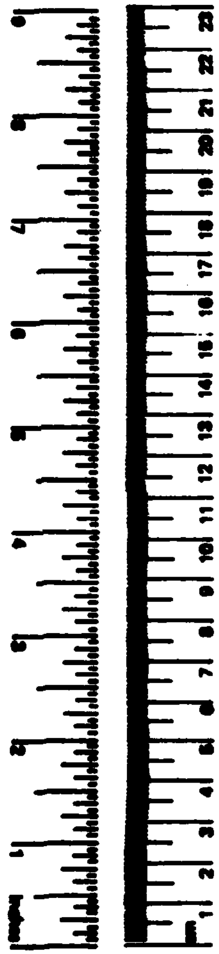
N00123-83-D-0118

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

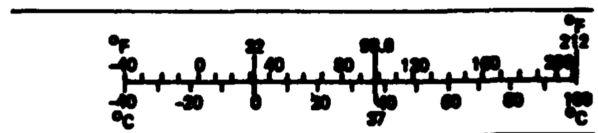
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2,000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1,000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER: CR 84.029 — 2. GOVT ACCESSION NO.: AD-A146443	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): User's Manual for the Heat Recovery Incinerator (HRI) Model	5. TYPE OF REPORT & PERIOD COVERED: Final, Feb 1984 - Jun 1984
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): James M. Ertman	8. CONTRACT OR GRANT NUMBER(s): N00123-83-D-0118
9. PERFORMING ORGANIZATION NAME AND ADDRESS: L.I. Dimmick Corporation, P.O. Box 2857, Oxnard, CA 93034	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 64710N.Z0371.01.421A/B
11. CONTROLLING OFFICE NAME AND ADDRESS: Naval Civil Engineering Laboratory, Port Hueneme, CA 93043	12. REPORT DATE: June 1984
	13. NUMBER OF PAGES: 52
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): Naval Facilities Engineering Command, 200 Stovall Street, Alexandria, VA 22332	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution is unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

heat recovery incinerators, solid waste, waste-to-energy, combustion, alternate fuels, computer model manual

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The manual enables user to exercise a model designed for Apple IIe microcomputer that will output standard cost/benefit analytical data for conceptual heat recovery incinerator (HRI) appropriate for users Activity. Inputting requires development of some preliminary design and operating information.

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SECTION 1

SYSTEM OVERVIEW

The system described in this manual is an automated mathematical model designed to aid in the evaluation and comparison of Heat Recovery Incinerators (HRIs). It can be used to compare HRIs or it can be used to compare the alternative of HRI implementation with the status quo alternative of fossil-fuel combustion for steam production and landfill disposal of all solid waste.

Outputs of the Model are printed out in the HRI Cost and Performance Report. There are six major outputs. In the first, the Model combines user inputs for the cost of capital, operation and maintenance, and system downtime due to failure to compute the life cycle cost of the proposed HRI. A user-entered discount factor (if no factor is entered, the Model defaults to 10 percent) is applied to all costs incurred over the project life of the system. (As exceptions, differential inflation rates for energy and landfill costs can be input to the Model.) The HRI life cycle cost can be compared to the sum of the costs of using a conventional fossil-fuel boiler to produce the equivalent of HRI life cycle Btu output and landfill disposition of all solid waste.

A second major output of the Model is the annual quantity (in barrels of oil equivalent) of virgin fuel offset through the use of the HRI. Depending upon the quantity of virgin fuel the HRI consumes (if any) per ton of solid waste burned, the Btu content of the waste and other offsetting fuels being burned, and the thermal efficiency and reliability of the proposed system, the HRI will offset to a varying degree the consumption of virgin fuel by a conventional boiler.

A third major output of the Model is the annual quantity (in tons) of landfill space conserved as a result of HRI implementation. Depending upon the type of waste being burned and the efficiency of the incinerators of the proposed system, the HRI will reduce the quantity of waste that must be transported to and disposed at a certified landfill site.

For comparisons to be made, the Report includes the discounted life cycle cost and savings of the HRI per ton of waste fired and per MBtu produced.

Two other major outputs of the Model are the HRI Savings-to-Investment Ratio (SIR) and the HRI total payback period (which includes project lead time). In addition, 13 other figures of merit are provided as outputs and are illustrated in Section 3.

The HRI Model consists of a main menu from which one of four options may be selected, eight data input screens, and the HRI Cost and Performance Report. (Figure 1-1 is a flow chart of the Model.) The main menu and the data input screens are discussed in Section 2. Section 3 covers the HRI Cost and Performance Report. Section 4 contains a description of the procedure used to create new data disks for the Model.

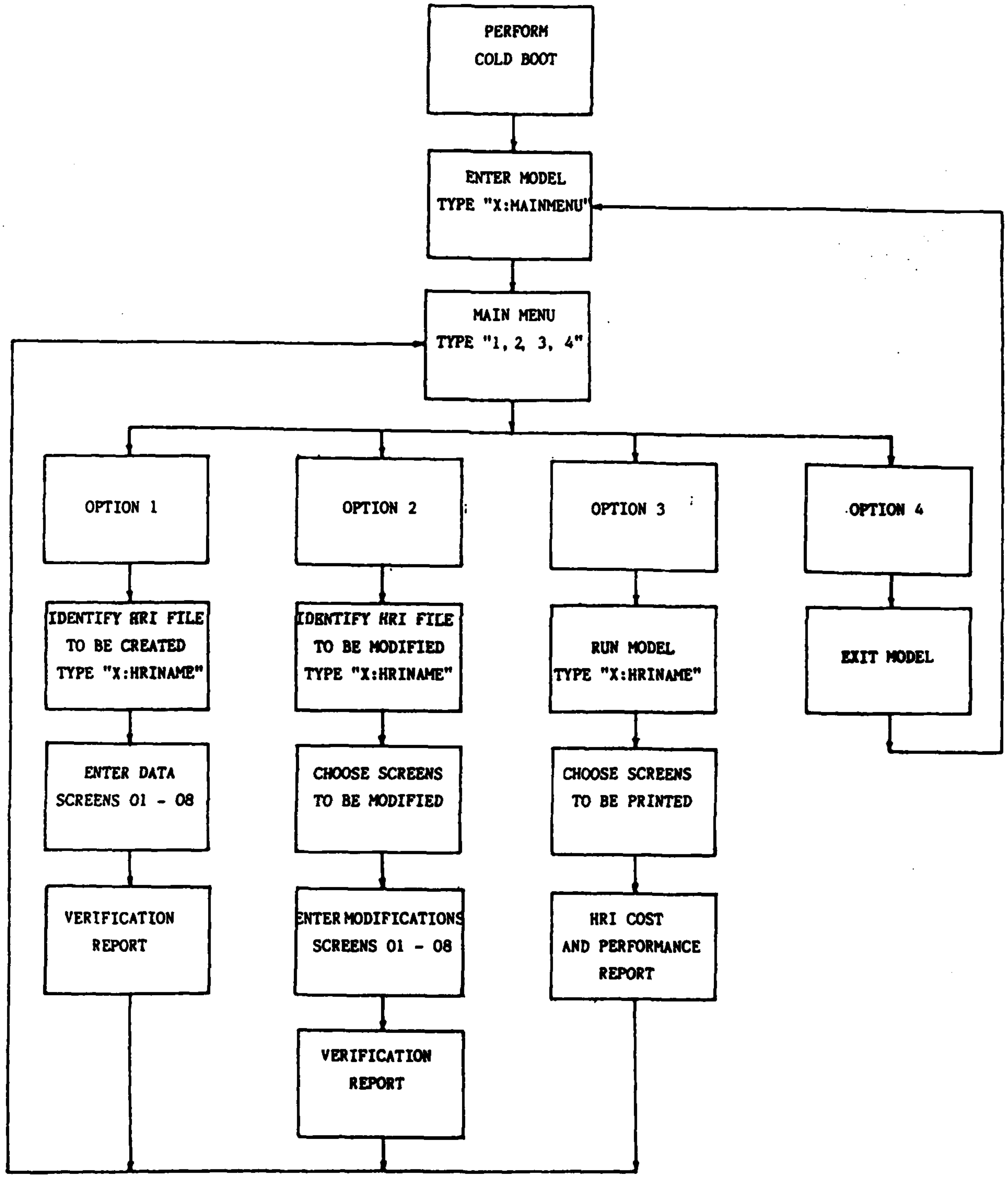

Figure 1-1. MODEL FLOW CHART

SECTION 2

INSTRUCTIONS FOR SYSTEM USE

2.1 HARDWARE NEEDED

The HRI Model is designed to run on an Apple computer with:

a. At least 60K bytes of memory

b. The Control Program for Microprocessors (CP/M) operating system

c. At least two floppy disk drives

d. A cursor addressable (24 lines by 80 columns) CRT device

e. A text printer

2.2 TO BOOT THE COMPUTER

Insert the system disk into Drive A and the desired data disk into a second drive. The computer should then be turned on. (This is called performing a "cold boot" of the computer using the system disk.) After the red light on Drive A has gone out, the CRT and the printer should be turned on. The CP/M operating system prompt "A " will appear.

2.3 TO ENTER THE MODEL

To enter the Model, type "DBASE X:MAINMENU" (where "X" identifies the disk drive containing the data disk) and depress the RETURN key. The Model's main menu, pictured in Figure 2-1, will then be displayed. Note the four choices provided. The user may:

a. Create a computer file containing data for an HRI for which a file does not already exist on the data disk (option 1).

b. Modify the data in a computer file for an HRI for which a file already exists on the data disk (option 2).

```
WELCOME TO THE HEAT RECOVERY INCINERATOR (HRI) MODEL

        1)   ENTER DATA FOR AN HRI FOR THE FIRST TIME

        2)   MODIFY DATA FOR AN EXISTING HRI

        3)   RUN THE HRI MODEL

        4)   STOP RUN
WAITING: :
```

Figure 2-1. MAIN MENU SCREEN

c. Run the HRI Model (option 3).

d. Exit the Model (option 4).

To make a selection, enter the option number. If an improper selection is made, a return to the main menu can be accomplished by depressing the RETURN key without making any other entry.

2.4 OPTION 4

If option 4 is selected, the HRI Model is exited and the user is again presented with the CP/M operating system prompt "A ". (At any time during the computer session following a display of the prompt "A ", the user may make use of the seven CP/M built-in commands that are discussed in the "Osborne CP/M User Guide" by Thom Hogan.) The user can reenter the HRI Model by typing "DBASE X:MAINMENU" and depressing the RETURN key.

2.5 OPTION 1

If the user selects option 1, 2, or 3, he will be presented with the screen pictured in Figure 2-2. If option number 1 is selected, the system will create a computer file which contains default values for several of the data items required by the Model. The new computer file must be named for identification. To enter the HRI Identification (ID), use the format "X:HRINAME" where "X" identifies the disk drive containing the data disk that is to contain the new HRI data file. "HRINAME" can consist of no more than eight characters, must begin with a letter, and can contain no colons or spaces.

```
PLEASE IDENTIFY THE HRI WITH WHICH YOU ARE WORKING.  MAKE
YOUR ENTRY IN THE FORM  X:HRINAME  WHERE X IS THE DISK DRIVE
CONTAINING THE DATA DISK AND HRINAME BEGINS WITH A LETTER,
CONTAINS NO COLONS OR SPACES, AND IS LIMITED TO 8 CHARACTERS.
TO START AGAIN, DO NOT MAKE AN ENTRY AND PRESS THE RETURN KEY.

           ===  :          :
```

Figure 2-2. IDENTIFICATION SCREEN

NOTE

> Should the user enter an HRI ID matching the name of a data file already in existence, the old data file will be replaced by a new one containing only the default values. This is probably not what is desired so caution should be used here.

Following the routine that creates the new data file, the user will be presented successively with the eight data input screens of the Model. On these screens, all data items required by the Model are entered. Default values may be changed as desired. Finally, the system edits the data entered on the eight input screens. A report identifying data entries inappropriate for Model execution is printed. Following the printing of the verification report, the user is returned to the main menu.

2.6 OPTION 2

Identify the HRI file to be modified. The system will check to see if a data file for the HRI identified exists on the disk drive specified. If the file exists, the user is presented the screen pictured in Figure 2-3. Screens containing input data that the user wishes to modify can then be selected following which the selected screens are presented and the desired modifications can be made. The edit routine is performed, the verification report is printed, and the user is returned to the main menu. If the HRI ID entered does not match that of a data file already in existence, the user will be presented the message "X:HRINAME DOES NOT EXIST. PRESS THE RETURN KEY TO REENTER." If this instruction is followed, the opportunity to reenter a valid HRI ID or exit to the main menu is provided the user.

```
TYPE AN 'X' BY EACH SCREEN YOU WISH TO VIEW/MODIFY.

: :  ALL EIGHT SCREENS
: :  SCREEN 01: GENERAL INFORMATION
: :  SCREEN 02: CAPITAL COSTS (EQUIPMENT, SUPPORT FACILITIES, CONSTRUCTION)
: :  SCREEN 03: CAPITAL COSTS (TOTAL, MODIFICATIONS, A&E)
: :  SCREEN 04: LABOR COSTS
: :  SCREEN 05: COST OF CONSUMABLES
: :  SCREEN 06: OTHER COSTS (PARTS, RESIDUE DISPOSAL, ETC.)
: :  SCREEN 07: OTHER COSTS (MISCELLANEOUS)
: :  SCREEN 08: OPERATING DATA
```

Figure 2-3. MODIFY SELECT SCREEN

2.7 OPTION 3

If option number 3 is selected and an HRI ID has been entered, again the system checks for a data file on the specified drive which matches the HRI ID entered. If the file exists, the system is prepared to begin execution of the computational portion of the HRI Model. The data file for the HRI identified is first copied to a file (called a work file) that will be used in the computational portion. A message informing the user of this copy routine is displayed on the CRT. Next, the user is presented the screen pictured in Figure 2-4. From this screen the user should select those data input screens he wishes to print. Paper copies of the selected screens displaying user-entered data items are then printed. The computational portion of the Model follows, the HRI Cost and Performance Report is printed, and the user is returned to the main menu.

If data items having values inappropriate for execution are input, the computational portion of the Model may abort. (At best, illogical results will be output in the HRI Cost and Performance Report.) Do not run the Model with a file containing data entries identified as invalid in the verification report. Because the edit routine may not identify all possible invalid entries, the computational portion of the Model may abort even though the verification report identifies no invalid entries. If the program aborts, the user can return to the main menu by typing "SYSTEM" following a display of the prompt "ok" or upon display of a blank line with cursor (small white square) in the left-most position. (A blank line can often be displayed by depressing the RETURN key.) Following an abort, the user should check paper copies of data input screens for inappropriate entries and/or use option 2 from the main menu in order to rerun the edit routine and print the verification report. Should this not identify any invalid entries, the system analyst should be contacted.

2.7 OPTION 3

If option number 3 is selected and an HRI ID has been entered, again the system checks for a data file on the specified drive which matches the HRI ID entered. If the file exists, the system is prepared to begin execution of the computational portion of the HRI Model. The data file for the HRI identified is first copied to a file (called a work file) that will be used in the computational portion. A message informing the user of this copy routine is displayed on the CRT. Next, the user is presented the screen pictured in Figure 2-4. From this screen the user should select those data input screens he wishes to print. Paper copies of the selected screens displaying user-entered data items are then printed. The computational portion of the Model follows, the HRI Cost and Performance Report is printed, and the user is returned to the main menu.

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```
TYPE AN 'X' BY EACH SCREEN YOU WISH TO VIEW/MODIFY.

: :  ALL EIGHT SCREENS
: :  SCREEN 01: GENERAL INFORMATION
: :  SCREEN 02: CAPITAL COSTS (EQUIPMENT, SUPPORT FACILITIES, CONSTRUCTION)
: :  SCREEN 03: CAPITAL COSTS (TOTAL, MODIFICATIONS, A&E)
: :  SCREEN 04: LABOR COSTS
: :  SCREEN 05: COST OF CONSUMABLES
: :  SCREEN 06: OTHER COSTS (PARTS, RESIDUE DISPOSAL, ETC.)
: :  SCREEN 07: OTHER COSTS (MISCELLANEOUS)
: :  SCREEN 08: OPERATING DATA
```

Figure 2-3. MODIFY SELECT SCREEN

TYPE AN 'X' BY EACH DATA SCREEN YOU WISH TO PRINT.

```
: :  ALL EIGHT SCREENS
: :  NONE OF THE SCREENS
: :  SCREEN 01: GENERAL INFORMATION
: :  SCREEN 02: CAPITAL COSTS (EQUIPMENT, SUPPORT FACILITIES, CONSTRUCTION)
: :  SCREEN 03: CAPITAL COSTS (TOTAL, MODIFICATIONS, A&E)
: :  SCREEN 04: LABOR COSTS
: :  SCREEN 05: COST OF CONSUMABLES
: :  SCREEN 06: OTHER COSTS (PARTS, RESIDUE DISPOSAL, ETC.)
: :  SCREEN 07: OTHER COSTS (MISCELLANEOUS)
: :  SCREEN 08: OPERATING DATA
```

Figure 2-4. PRINT SELECT SCREEN

2.8 DATA INPUT SCREENS

Should the user opt to create a new HRI data file he will be presented successively with eight data input screens, the first of which is pictured in Figure 2-5. Upon initial display of the input screen, the cursor will be positioned in the one-character field following the prompt, "IS EVERYTHING CORRECT (Y/N)?" (Colons will appear on the screen outlining blank spaces in which the user will make his entries. A set of these spaces is called a field. In figures depicting data input screens, "9's" are used to indicate that a field requires a numeric entry, "X's" are used to indicate that a field accepts alphanumeric data.) If no changes are to be made to the screen, the character "Y" should be typed in this field. The user will be presented with the second data input screen. If changes are to be made, the character "N" should be entered. (It is not necessary to depress the RETURN key after an entry of "Y" or "N".) The cursor will move directly to the field of the first data item on the screen. Nearly all fields on the input screens are numeric fields. This means that the only allowable entries for characters in these fields are digits (1, 2, ...9, 0) and the characters ".", "+", "-", and " " (a space). The cursor can be moved from field to field down the screen by filling up a data field or depressing the RETURN key. If an error is made within a field, the character "←" may be used to move leftward <u>within</u> a data field in order to rekey an entry. The "←" key should <u>not</u> be used, however, to move the cursor to a data field appearing prior to the field where the cursor is currently positioned, i.e., the user should not attempt to move the cursor up the screen. To make a modification to a prior field, the cursor should be moved downward from its current position to the bottom of the screen, the prompt "IS EVERYTHING CORRECT (Y/N)?" should be answered "N", and the cursor should be moved downward from the top of the screen to reach the

```
                    ***  GENERAL INFORMATION  ***            SCREEN 01
              CURRENT MONTH: 99        CURRENT YEAR: 99

                      ***  NEAR-TERM FUTURE  ***
           NUMBER OF MONTHS BETWEEN ANALYSIS AND FUNDING: 99
            ANNUAL INFLATION RATES FOR THE FOLLOWING:
                    CAPITAL EXPENDITURES: 99.9
                                  ENERGY: 99.9
                          LANDFILL COSTS: 99.9
                  ALL OTHER EXPENDITURES: 99.9

                     ***  PROJECT LEAD TIME  ***
             ARCHITECT/ENGINEER(%)       CAPITAL COSTS(%)
       YEAR 1      99.9                       99.9
       YEAR 2      99.9                       99.9     (NOTE: PERCENTAGES
       YEAR 3      99.9                       99.9       MUST ADD TO 100)
       YEAR 4      99.9                       99.9
       YEAR 5      99.9                       99.9

                   ***  PROJECT ECONOMIC LIFE  ***
ECONOMIC LIFE OF HRI IN YEARS:  99             DISCOUNT RATE (%):  99
DIFFERENTIAL INFLATION RATES (%) FOR ENERGY:  99     AND LANDFILL:  99

                   IS EVERYTHING CORRECT (Y/N)?: :
```

Figure 2-5. SCREEN 01

field requiring modification. If "←" is inadvertently depressed and the cursor moves to a prior field, the entry in the current field will, following a RETURN (and no other entry), replace on the screen the entry in the prior field. The entry in the prior field, however, is not changed in the HRI file. Some of the numeric fields contain decimal points; these can be seen in several of the data items on Screen 01. These are system-assigned decimal points. A decimal point need never be entered in a data field. Entry of a "." will cause digits entered to the right of the decimal point to be lost. If this occurs, the user should return to the field by moving forward through the data items on the screen. Following a short period of experience with the data screens, such difficulties can be avoided.

In the following text, "near-term future" refers to the period from the present to the point of initial funding. During this period the project must be approved and funding must be authorized and appropriated, all prior to the initial investment expenditure. The "project life" follows and consists of "project lead time" (the time that elapses between initial funding and the date of beneficial occupancy) and the "economic life" immediately following. All costs are first inflated to the point of initial funding. They are then, depending upon where they are incurred during the project life, discounted to the point of initial funding. Valid entries for some of the data fields on the eight data input screens are discussed next.

2.9 SCREEN 01

a. CURRENT MONTH: Must be between 1 and 12 inclusive.

b. CURRENT YEAR: Must be positive.

The current date is used to inflate costs to the point of initial funding. It should be checked for accuracy each time the Model is run.

c. NUMBER OF MONTHS BETWEEN ANALYSIS AND FUNDING: Must be positive. Should identify the time that will elapse between the Model run and the point of initial project funding.

d. ANNUAL INFLATION RATES FOR

CAPITAL EXPENDITURES:

ENERGY:

LANDFILL COSTS:

ALL OTHER EXPENDITURES:

Must be nonnegative percentages. These percentages will be used to inflate all user-entered costs to the point of initial funding, i.e., to inflate all user-entered costs over the near-term future. (All Other Expenditures includes items such as labor, waste and other fuels, water, repair parts, insurance, etc.)

e. PROJECT LEAD TIME ARCHITECT/ENGINEER SERVICES: Must be nonnegative percentages. These percentages are used to allocate the cost of architect and engineer services to the various years of project lead time and must total 100. (On Screen 03, the user identifies the cost of architect and engineer services as a percentage of all capital costs which are entered on Screens 02 and 03.) If applicable, the costs of Supervision, Inspection, and Overhead (SIOH) should be incorporated in these percentages. As many as 5 years of project lead time can be accommodated.

f. PROJECT LEAD TIME CAPITAL COSTS: Must be nonnegative percentages that total 100. These percentages are used to allocate total project lead time capital costs to the various years of project lead time. (Capital costs are entered on Screens 02 and 03.)

g. ECONOMIC LIFE OF HRI IN YEARS: Must be between 1 and 25 inclusive. Should identify the length of time between project beneficial use and project termination.

h. DISCOUNT RATE (%): Should be a positive percentage. This rate will be used in discounting costs incurred during the project life to the point of initial funding.

i. DIFFERENTIAL INFLATION RATES (%) FOR

ENERGY:

LANDFILL:

Can be positive or negative percentages. If the costs of energy and/or landfill disposal over the project life of the HRI are expected to escalate at rates different from the average long-term general rate, differential inflation rates (the expected difference, positive or negative, between the average long-term general rate and the long-term rate for energy or landfill disposal) are entered in these fields. If inflation rates over the HRI project life are not expected to differ significantly from the near-term future rates entered in (d.) above, the user may obtain an estimate of the differential inflation rate for energy, for example, by subtracting the average of the near-term rates for Capital and All Other Expenditures from the near-term rate for Energy Expenditures.

2.10 SCREEN 02 (Figure 2-6).

Capital costs are broken out into costs for equipment, support facilities, and construction and setup. The choice of these categories is merely an effort to assist the user in identifying all capital costs to be incurred and the categories may be used as desired. On Screen 03, the user may choose,

```
                  ***  CAPITAL COST FOR EQUIPMENT  ***            SCREEN 02
                              YEAR $:   99
         ITEM                        COST              ITEM                  COST
RECEIVING:                          9999999  QUENCH TANK WATER TREATMENT:   9999999
PROCESSING:                         9999999  BOILER WATER TREATMENT:        9999999
STORAGE:                            9999999  INSTRUMENTATION:               9999999
RETRIEVAL:                          9999999  CONTROL SYSTEM:                9999999
INCINERATION:                       9999999  FIRE AND EXPLOSION SUPPRESSION
BOILER:                             9999999       EQUIPMENT:                9999999
ASH REMOVAL:                        9999999  INITIAL SPARE PARTS INVENTORY: 9999999
AIR POLLUTION:                      9999999  OTHER:                         9999999
                                                      TOTAL:               99999999

               ***  CAPITAL COST FOR SUPPORT FACILITIES  ***
                              YEAR $:   99
                      ITEM                              COST
                 BUILDING:                              9999999
                 UTILITIES:                             9999999
                 EARTH WORK AND ROAD CONSTRUCTION:      9999999
                 OTHER:                                 9999999
                         TOTAL:                        99999999
             ***  CAPITAL COST FOR CONSTRUCTION AND SETUP  ***
                         YEAR$:  99       TOTAL: 9999999
                      IS EVERYTHING CORRECT (Y/N)?: :
```

Figure 2-6. SCREEN 02

instead, to enter a figure for HRI total capital cost. Also on Screen 03, the cost for architect and engineer services (including SIOH) is entered as a percentage of all capital costs and, therefore, should not be included in any of the capital costs.

a. CAPITAL COST FOR EQUIPMENT YEAR $: Enter the year in which prices for the cost are estimated. Must be positive and less than or equal to the figure entered for Current Year. This figure is used to inflate equipment costs to the point of initial funding.

b. CAPITAL COST FOR EQUIPMENT: The user may enter the erected costs for the individual equipment items or a total equipment cost. If entries are made for both the total and one or more individual items, the total entered will be the figure used in the Model.

c. CAPITAL COST FOR SUPPORT FACILITIES YEAR $: Must be positive and less than or equal to the figure entered for Current Year. This figure is used to inflate support facility costs to the point of initial funding.

NOTE

The above comments apply analogously to all remaining "YEAR $" entries. If, for a user-entered cost, the figure entered for YEAR $ is not positive or is greater than the figure entered for Current Year, the Model takes the value of Current Year for YEAR $.

d. CAPITAL COST FOR SUPPORT FACILITIES: The user may enter the costs for the erected individual support facility items or a total support facility cost. If entries are made for both the total and one or more individual items, the total entered will be the figure used in the Model.

2.11 SCREEN 03 (Figure 2-7)

a. TOTAL CAPITAL COST: Instead of entering capital costs for equipment, support facilities, and construction and setup on Screen 02, the user may enter a total capital cost figure on Screen 03. If entries are made for both the total and one or more of the former, the total entered will be the figure used in the Model. Capital expenditures incurred after HRI startup should be entered in the the area Capital Cost for Expected Modifications.

b. CAPITAL COST FOR EXPECTED MODIFICATIONS: Ten lines are provided to identify the timing and costs of expected installed major modifications to the HRI.

c. DESCRIPTION OF MODIFICATION: This is a 10-character field in which any character may be entered.

d. ECONOMIC LIFE YEAR: If a Modification Cost is entered, the Economic Life Year of the cost must be specified. The figure entered for Economic Life Year should indicate the year within the economic life of the HRI that the modification cost is incurred. A figure for Year $ must also be entered. Economic Life Year must be positive and not greater than the figure entered for HRI economic life.

e. CAPITAL COST FOR ARCHITECT AND ENGINEER SERVICES: Here the user must enter a nonnegative percentage identifying an estimate of the cost of architect and engineer services as a percentage of all capital costs entered on Screens 02 and 03. If applicable, the cost of SIOH should be incorporated in this estimate.

*** TOTAL CAPITAL COST *** SCREEN 03

YEAR $: 99 TOTAL: 99999999

*** CAPITAL COST FOR EXPECTED MODIFICATIONS ***

YEAR $: 99

DESCRIPTION OF MODIFICATION	MODIFICATION COST	ECONOMIC LIFE YEAR
XXXXXXXXXX	9999999	99
XXXXXXXXXX	9999999	99
XXXXXXXXXX	9999999	99
XXXXXXXXXX	9999999	99
XXXXXXXXXX	9999999	99
XXXXXXXXXX	9999999	99
XXXXXXXXXX	9999999	99
XXXXXXXXXX	9999999	99
XXXXXXXXXX	9999999	99
XXXXXXXXXX	9999999	99

*** CAPITAL COST FOR ARCHITECT AND ENGINEER SERVICES ***

PERCENTAGE OF ALL CAPITAL COSTS IDENTIFIED ABOVE: 99.9

IS EVERYTHING CORRECT (Y/N)?: :

Figure 2-7. SCREEN 03

2.12 SCREEN 04 (Figure 2-8)

a. OPERATION LABOR: The user should enter for each of the categories Supervisory, Skilled, and Unskilled a total labor cost or figures for no downtime annual operation manhours and hourly rates (burdened).

NOTE

All labor rates entered should be burdened, where appropriate, by the costs of overhead, General and Administrative (G&A), fees, etc. However, inasmuch as many overhead costs are already entered in the Model, it is recommended that rates be burdened by G&A and fees only. In case of lack of information, a 40 percent rate is suggested.

The user should also enter, for each of the categories, the percentage (0 and 100) of operation labor that is reassigned to corrective maintenance or stand-around time during downtime due to failure, i.e., operation labor that is not sent home or reassigned to other duties charged to another activity. The Model will compute the actual cost of operation labor by considering downtime data (entered on Screen 08) and will add the cost of operation labor assigned to corrective maintenance or stand-around time during unscheduled downtime (downtime due to failure) to the cost of outside corrective maintenance labor entered for CORRECTIVE MAINTENANCE to obtain a total corrective maintenance labor cost. If a figure for total operation labor cost is entered, the HRI is debited this cost for operation labor regardless of the downtime data entered and all corrective maintenance labor is assumed to be performed by outside personnel.

*** LABOR COSTS *** SCREEN 04
YEAR $: 99

NO DOWNTIME

ASSIGNED TO OPERATION DOWNTIME(%)	ANNUAL MANHOURS(MHR)	RATE ($/HR)	TOTAL	
SUPERVISORY	99999	99.99	999999	999
SKILLED	99999	99.99	999999	999
UNSKILLED	99999	99.99	999999	999

TOTAL OPERATION LABOR COST: 9999999

PREVENTIVE MAINTENANCE	ANNUAL MANHOURS(MHR)	RATE ($/HR)	TOTAL
SUPERVISORY	99999	99.99	999999
SKILLED	99999	99.99	999999
UNSKILLED	99999	99.99	999999

TOTAL PREVENTIVE MAINTENANCE LABOR COST: 9999999

CORRECTIVE MAINTENANCE	MHR/CORRECT MAINT HR	RATE ($/HR)
SUPERVISORY	99.9	99.99
SKILLED	99.9	99.99
UNSKILLED	99.9	99.99

TOTAL CORRECTIVE MAINTENANCE LABOR COST: 9999999

IS EVERYTHING CORRECT (Y/N)?: :

Figure 2-8. SCREEN 04

b. PREVENTIVE MAINTENANCE LABOR: The user may enter either a figure for total preventive maintenance labor cost; total labor costs for each of the categories Supervisory, Skilled, and Unskilled; or figures for annual man-hours and hourly rates (burdened) for each of the three categories. The Model uses first, the total preventive maintenance labor cost if given, second, any total labor costs for any of the three categories given, or, last, the annual man-hours and hourly rates for the three categories to compute preventive maintenance labor costs.

c. CORRECTIVE MAINTENANCE LABOR: The user may enter either a figure for total corrective maintenance labor cost or, for each of the categories Supervisory, Skilled, and Unskilled, the number of man-hours per hour of corrective maintenance downtime (downtime due to failure) and hourly rates (burdened). (Annual downtime due to failure is estimated by the user as a percentage of planned annual operating hours and entered on Screen 08.) These entries apply only to corrective maintenance performed by outside personnel. If a figure for the total is entered, the Model uses this figure and disregards entries for man-hours and rates. In this case, should the user change significantly his estimate of downtime due to failure, he should also change his estimate of the cost of corrective maintenance labor.

2.13 SCREEN 05 (Figure 2-9)

a. ELECTRICITY: Here the user should enter an estimate of the number of kWh consumed by the HRI per operating hour, the cost per kWh, the quantity of kWh consumed per HRI downtime hour (expressed as a percentage of kWh per operating hour), and th quantity of kWh

```
                        ***  COST OF CONSUMABLES  ***              SCREEN 05
                                YEAR $:   99
ELECTRICITY:          KWH/OPERATING HR:  9999        $/KWH:  9.999
                          KWH/DOWNTIME HR (% OF KWH/OP HR):  99.9
                    KWH/SCHEDULED NON-OP HR (% OF KWH/OP HR):  99.9

WASTE AND OTHER FUELS THAT OFFSET               VIRGIN GAS AND LIQUID FUELS
  USE OF VIRGIN FUELS
           GAL/TON     $/GAL      BTU/GAL          GAL/TON     $/GAL      BTU/GAL
LIQUID:    99.999       9.99      999999           99.999       9.99      999999
       1000 CF/TON  $/1000 CF  BTU/1000 CF   1000 CF/TON  $/1000 CF  BTU/1000 CF
GAS:       99.99      99.99      9999999           99.99      99.99      9999999
           TON/TON     $/TON      BTU/TON
SOLID:      9.99      99.99      9999999
SOLID:      9.99      99.99      9999999

MAKEUP WATER:   GAL/TON: 99999    $/1000 GAL: 99.99    OR ANNUAL TOTAL: 9999
CHEMICALS:
    CHEMICAL    UNITS/1000 GAL MAKEUP WATER    $/UNIT    OR    ANNUAL TOTAL
     XXXXX            99.99                     99.99              9999
     XXXXX            99.99                     99.99              9999
                                TOTAL ANNUAL COST OF CHEMICALS: 99999
                         IS EVERYTHING CORRECT (Y/N)?: :
```

Figure 2-9. SCREEN 05

consumed per HRI scheduled nonoperating hour (again expressed as a percentage of kWh per operating hour).

b. WASTE AND OTHER FUELS THAT OFFSET USE OF VIRGIN FUELS: The user should make entries for each HRI co-fired fuel (e.g., waste oil, landfill gas, sewage sludge, wood chips, coal) that offsets the firing of virgin gas and liquid fuels for the production of steam. Space is provided for the entry of one liquid, one gas, and two solid offsetting fuels. For the liquid fuel, the user should enter the number of gallons consumed per HRI ton of waste burned, the cost per gallon, and the fuel heating value in Btus per gallon. For the gas fuel, the user should enter the number of cubic feet (in thousands) consumed per ton of waste burned, the cost per one thousand cubic feet, and the fuel heating value in Btus per one thousand cubic feet. For the solid fuels, the user should enter the number of tons consumed per ton of waste burned, the cost per ton, and the fuel heating value in Btus per ton. (Fuel consumption rates entered should be average rates.)

c. VIRGIN GAS AND LIQUID FUELS: The user should make entries for virgin fuels (e.g., natural gas and prime distillate or residual petroleum fuels) consumed. Space is provided for the entry of one liquid and one gas virgin fuel. Entries required are the same as those for the co-fired offsetting fuels.

d. MAKEUP WATER: Here the user should enter the total annual cost of makeup water or the number of gallons of makeup water required per HRI ton of waste burned and the cost per 1,000 gallons. The Model uses first, the total if given, and second, the figures for gallons/ton and cost/1,000 gallons to compute the cost of makeup water.

e. CHEMICALS: Two lines are provided to identify chemicals used by the HRI. For each chemical, the user should enter a description (a five-character field is provided), and either the number of units consumed per 1,000 gallons of makeup water and the cost per unit or an annual total. The user may choose instead to enter a total annual cost for all chemicals. The Model uses first, the total annual chemical cost if given; second, the total annual cost per chemical if given; or last, the units/1,000 gallons of makeup water and cost/unit to compute the cost of chemicals.

2.14 SCREEN 06 (Figure 2-10)

RESIDUE DISPOSAL: In the event that noncombustible waste, ash, or waste of the type generated at the HRI site must be disposed at different landfills, the user is provided the opportunity to enter separately the figures of merit for each of these three disposal categories. For each category, the user should enter either the per-ton total cost of disposal or the transportation cost per ton-mile, the number of miles to the landfill, and the per-ton tipping fee at the landfill. If a per-ton total is entered, the figure is used by the Model. (The Model requires that appropriate figures of merit be entered for disposal of each of noncombustible waste, ash, and waste of the type generated at the site. If they are not, the Model calculates the cost of the particular item as zero.)

2.15 SCREEN 07 (Figure 2-11)

OTHER COSTS: Ten lines are provided for the user to enter any costs not identified on any other input screen. For each such cost, a 10-character description field is provided. On any one line, the user should enter an

```
                         ***  OTHER COSTS ***                        SCREEN 06
 ITEM                   ANNUAL COST          YEAR $
REPAIR PARTS               99999               99
SEWER                      99999               99
INSURANCE                  99999               99
PEST/VERMIN CONTROL        9999                99
RESIDUE DISPOSAL                          YEAR $: 99
    (ENTRIES MUST BE MADE FOR EACH OF THE FOLLOWING THREE GROUPS)
       TRANSPORTATION COST OF NONBURNABLE WASTE ($/TON-MILE):  99.99
       NUMBER OF MILES TO NONBURNABLE WASTE LANDFILL:          999
       TIPPING FEE AT NONBURNABLE WASTE LANDFILL ($/TON):      99.99
    OR COST OF LANDFILL DISPOSAL OF NONBURNABLE WASTE ($/TON): 99.99

       TRANSPORTATION COST OF ASH ($/TON-MILE):                 99.99
       NUMBER OF MILES TO ASH DISPOSAL LANDFILL:                999
       TIPPING FEE AT ASH DISPOSAL LANDFILL ($/TON):            99.99
    OR COST OF LANDFILL DISPOSAL OF ASH ($/TON):                99.99

       TRANSPORTATION COST OF ALL WASTE GENERATED ($/TON-MILE): 99.99
       NUMBER OF MILES TO LANDFILL:                             999
       TIPPING FEE AT LANDFILL ($/TON):                         99.99
    OR COST OF LANDFILL DISPOSAL OF ALL WASTE ($/TON):          99.99
                        IS EVERYTHING CORRECT (Y/N)?: :
```

Figure 2-10. SCREEN 06

*** OTHER COSTS *** SCREEN 07

ITEM	ANNUAL COST	ECONOMIC LIFE YEAR AND COST		TYPE COST (C,E,L, OR O)	YEAR $
XXXXXXXXXX	9999999	99	9999999	X	99
XXXXXXXXXX	9999999	99	9999999	X	99
XXXXXXXXXX	9999999	99	9999999	X	99
XXXXXXXXXX	9999999	99	9999999	X	99
XXXXXXXXXX	9999999	99	9999999	X	99
XXXXXXXXXX	9999999	99	9999999	X	99
XXXXXXXXXX	9999999	99	9999999	X	99
XXXXXXXXXX	9999999	99	9999999	X	99
XXXXXXXXXX	9999999	99	9999999	X	99
XXXXXXXXXX	9999999	99	9999999	X	99

IS EVERYTHING CORRECT (Y/N)?: :

Figure 2-11. SCREEN 07

annual cost or an economic life year and one-time cost. For a one-time cost, the economic life year must be positive and not greater than the HRI economic life. For each cost entered, the type of cost must be specified as capital (C), energy (E), landfill (L), or other (O). This is needed in order to determine the inflation rate to be used by the Model. Also, for each cost entered, a positive figure for Year $ must be entered.

2.16 SCREEN 08 (Figure 2-12)

a. TONS OF NONBURNABLE WASTE/TON OF WASTE: Here the user should enter a number between 0 and 1 inclusive that represents the fraction of solid waste generated that is nonburnable (i.e., the fraction of front-end waste that is rejected).

b. ESTIMATE OF HRI COMBUSTION RATE (TONS/HOUR): Here the user should enter an estimate of the average combustion rate of the HRI in tons of combustible waste burned per operating hour.

c. HRI TURN-UP CAPABILITY (PERCENT ABOVE NORMAL FIRING RATE): If the HRI combustion rate can be increased following a failure in order that all waste normally burned during the failure need not be disposed at the landfill, the user should enter the increased combustion rate here. The increase should be in terms of the percentage above the normal firing rate. The Model assumes that the HRI can burn at the increased rate until trash in storage at the end of a day is less than that normally in storage. If no such turn-up capability exists, the user should enter zero in this field.

d. TONS OF ASH (BOTTOM OR FLY)/TON OF BURNED WASTE: A number between 0 and 1 inclusive should be entered here. The figure should represent the number of tons of ash remaining following the combustion of a ton

```
                    ***  OPERATING DATA  ***                    SCREEN 08

TONS OF NONBURNABLE WASTE/TON OF WASTE:                         9.999
ESTIMATE OF HRI COMBUSTION RATE (TONS/HOUR):                     9.99
HRI TURN-UP CAPABILITY (PERCENT ABOVE NORMAL FIRING RATE):       99.9
TONS OF ASH (BOTTOM OR FLY)/TON OF BURNED WASTE:                 9.99
$/MBTU OUTPUT OF FOSSIL FUEL BOILER AND YEAR $:                  99.99  99
THERMAL EFFICIENCY OF FOSSIL FUEL BOILER (%):                    99.9
HEATING VALUE OF BURNABLE WASTE (BTU/TON):                       99999999
HRI FURNACE TYPE (R=REFRACTORY, W=WATER WALL):                   X
THERMAL EFFICIENCY OF THE HRI (%)                                99.9
ESTIMATE OF HRI TOTAL ANNUAL DOWNTIME DUE TO FAILURE (%):        99
ESTIMATE OF HRI ANNUAL NUMBER OF FAILURES:                       999
ESTIMATE OF MAXIMUM HRI DOWNTIME (HOURS):                        999
TIME REQUIRED TO COMPLETE A DAYS DELIVERY (HOURS):               99
STORAGE SPACE AVAILABLE AT HRI (TONS):                           999
HRI OPERATING SCENARIO:
   1=BURN 2 SHIFTS, 5 DAYS   2=BURN CONTINUOUSLY, 5 DAYS          9
   3=BURN 2 SHIFTS, 7 DAYS   4=BURN CONTINUOUSLY, 7 DAYS
   5=BURN CONTINUOUSLY, 4 DAYS, FOLLOWING DAY 1 RECEIPT
HRI PLANNED ANNUAL OPERATING WEEKS:                               99

                    IS EVERYTHING CORRECT (Y/N)?: :
```

Figure 2-12. SCREEN 08

of combustible waste and should include any residual solid auxiliary fuel and water.

e. $/MBTU OUTPUT OF FOSSIL FUEL BOILER AND YEAR $: A figure representing the per-MBtu cost of the fossil-fuel boiler with which the HRI is being compared should be entered here. Year $ must be positive and not greater than Current Year.

f. ESTIMATE OF HRI TOTAL ANNUAL DOWNTIME DUE TO FAILURE (%): This estimate should be given as a percentage of planned annual operating hours where planned annual operating hours indicates the number of hours the HRI would be operational if it never failed and is computed by the Model using entries for operating scenario and planned annual operating weeks. (Actual operating hours are thus planned operating hours minus downtime due to failure.)

g. ESTIMATE OF MAXIMUM HRI DOWNTIME (HOURS): The user should enter the length of a downtime (due to failure) that is expected to be exceeded by only 5 percent of all failure downtimes.

h. The distribution of HRI downtimes (due to failure) is assumed to be log-normal. According to "Reliability Engineering," ARINC Research Corporation, 1964, past data shows this to be a reasonable assumption. Because of this assumption, HRI MAXIMUM DOWNTIME must be greater than HRI average downtime and must be less than 3.8 x HRI average downtime where HRI average downtime is computed (by the Model) using entries for operating scenario, planned annual operating weeks, and annual number of failures. If these conditions are not satisfied, the user will be informed in the Verification Report.

i. TIME REQUIRED TO COMPLETE A DAY'S DELIVERY (HOURS): The user should enter the elapsed time at the HRI spent receiving a daily delivery of waste. The number entered must be positive and not greater than daily burn time as identified in the HRI operating scenario on Screen 08.

j. STORAGE SPACE AVAILABLE AT HRI (TONS): This figure should identify the total capacity (in tons) of the HRI's tipping pit or pits. In the two 7-day operating scenarios, the quantity of waste in storage at the HRI at the end of each day must increase in order that there be waste to burn over the weekend. If the figure entered for storage space is not sufficient to operate using the 7-day scenario entered, the user will be so informed in the Verification Report. The Model checks for sufficient storage space for the 4- and 5-day scenarios also.

k. HRI OPERATING SCENARIO: Five operating scenarios are accommodated by the Model. They are:

(1) HRI fires for two shifts daily, 5 consecutive days per week

(2) HRI fires continuously 5 days per week

(3) HRI fires for two shifts daily, 7 days per week

(4) HRI fires continuously 7 days per week

(5) HRI fires continuously for 4 days following the receipt of the first day's delivery

The user should enter the number of the operating scenario that most closely matches the scenario to be used.

l. HRI PLANNED ANNUAL OPERATING WEEKS: Must be between 1 and 52 inclusive.

SECTION 3

THE REPORT

Figure 3-1 is a sample of the HRI Cost and Performance Report output by the Model. Equations used in the derivation of the items on this Report are included in this section.

a. INFLATED PER TON COST OF DISPOSING WASTE OF THE TYPE GENERATED AT THE SITE TO THE LANDFILL: On data input Screen 06, the user enters either the per-ton Cost of Landfill Disposal of all Waste or the Transportation Cost of all Waste Generated ($/ton), the Number of Miles to the Landfill, and the Tipping Fee at the Landfill. (If the latter three entries are made, the product of the first two is added to the third to get a per-ton cost.) This per-ton cost is inflated to the point of initial funding using the formula

$$(1) \quad CWD_{inf} = CWD\,(1 + I_1 / 100)^N$$

where CWD = per-ton cost of landfill disposal

I_1 = inflation rate for landfill costs

and N is the period of time between the Residue Disposal Year $ entered and the point of initial funding. The figure N is computed by subtracting the month (assumed to be mid-year and thus 6) and year of Residue Disposal Year $ from the month and year of the HRI initial funding date. Landfill Inflation Rate is entered on Screen 01.

b. INFLATED PER MBTU COST OF THE FOSSIL FUEL BOILER TO WHICH THE HRI IS BEING COMPARED: On Screen 08, the user enters $/MBTU Output of the

HRI COST AND PERFORMANCE REPORT

INFLATED PER TON COST OF DISPOSING WASTE OF THE TYPE GENERATED AT THE SITE TO THE LANDFILL	$31.73
INFLATED PER MBTU COST OF THE FOSSIL FUEL BOILER TO WHICH THE HRI IS BEING COMPARED	$10.38
TONS OF TRASH BURNED ANNUALLY BY THE HRI:	10,800
MBTUS PRODUCED ANNUALLY BY THE HRI (CONSIDERING NO DOWNTIME):	4.66E+04
VIRGIN FUEL OFFSET ANNUALLY BY THE HRI IN BARRELS-OF-OIL-EQUIVALENT	8,114
LANDFILL SPACE CONSERVED ANNUALLY BY THE HRI IN TONS	7,884
COST OF USING A BOILER TO PRODUCE THE ANNUAL NO-DOWNTIME QUANTITY OF STEAM PRODUCED BY THE HRI AND LANDFILLING ALL WASTE:	$949,623
INFLATED TOTAL CAPITAL COST OF THE HRI (INCLUDES EQUIPMENT, SUPPORT FACILITIES, AND CONSTRUCTION AND SETUP)	$2,259,450
UNIFORM ANNUAL COST OF THE HRI (THE COST OF CAPITAL, MODIFICATIONS, LABOR, CONSUMABLES, RESIDUE DISPOSAL, DOWNTIME, AND OTHER COSTS SPREAD OVER THE ECONOMIC LIFE OF THE HRI):	$802,985
ANNUAL NO-DOWNTIME COST OF THE HRI (THE TOTAL OF NO-DOWNTIME COSTS SPREAD OVER THE ECONOMIC LIFE OF THE HRI)	$787,041
DISCOUNTED LIFE CYCLE COST OF USING A BOILER TO PRODUCE THE LIFE CYCLE NO-DOWNTIME QUANTITY OF STEAM PRODUCED BY THE HRI AND LANDFILLING ALL WASTE (COSTS DISCOUNTED TO THE POINT OF INITIAL FUNDING)	$8,626,650
DISCOUNTED LIFE CYCLE COST OF THE HRI:	$5,282,240
DISCOUNTED LIFE CYCLE COST OF AUXILIARY FUELS USED BY THE HRI.	$72,215
DISCOUNTED LIFE CYCLE COST OF NONCOMBUSTIBLE WASTE, ASH, AND SCHEDULED DOWNTIME WASTE DISPOSAL	$1,613,510
DISCOUNTED LIFE CYCLE COST OF HRI DOWNTIME:	$147,695
DISCOUNTED LIFE CYCLE COST OF THE HRI PER TON OF WASTE FIRED:	$24.45
DISCOUNTED LIFE CYCLE SAVINGS OF THE HRI PER TON OF WASTE FIRED:	$23.96
DISCOUNTED LIFE CYCLE COST OF THE HRI PER MBTU PRODUCED:	$6.30
DISCOUNTED LIFE CYCLE SAVINGS OF THE HRI PER MBTU PRODUCED:	$6.17
DISCOUNTED LIFE CYCLE SAVINGS OF THE HRI:	$5,175,440
HRI SAVINGS-TO-INVESTMENT RATIO:	+2.83
PAYBACK PERIOD IN YEARS (INCLUDES PROJECT LEAD TIME)	10.3

Figure 3-1. HRI COST AND PERFORMANCE REPORT

Fossil Fuel Boiler and Year \$. These figures are used to compute the inflated per-MBtu cost of fossil fuel boiler steam production

$$(2) \quad CSP_{inf} = CSP\ (1 + I_e\ /\ 100)^N$$

where

CSP = per-MBtu cost of boiler steam production

I_e = inflation rate for energy costs

and N is the period of time between the Year \$ entered and initial funding.

c. TONS OF TRASH BURNED ANNUALLY BY THE HRI: To get an estimate of the actual number of annual tons of waste burned by the HRI, entries for operating scenario, the time for a days delivery, storage space, turn-up capability, downtime percentage, and annual number of failures are used. (If no HRI turn-up capability exists, the number of tons fired is just the number of actual operating hours times the HRI combustion rate). The entries for operating scenario and the downtime data entered are used to compute an average failure time. The Model then simulates a failure of average duration occurring during each of the HRI's operating periods (periods during which the HRI is either receiving and burning waste or just burning waste). The quantity of waste in storage at the time of the failure, the timing and rate at which waste is received, the quantity of storage space available, and the turn-up capability are all used to identify the quantity of waste that cannot be stored and later burned and must be sent to the landfill. Assuming that the occurrence of a failure is equally likely at any moment during HRI combustion, the waste lost during an average failure is calculated. (HRI time spent firing at the increased rate is also determined.) This figure is then multiplied by the userentered number of annual failures to compute annual tons lost. This figure is subtracted from planned tons burned to arrive at actual tons burned.

d. MBTUS PRODUCED ANNUALLY BY THE HRI (CONSIDERING NO DOWNTIME): Fuel equivalent Btus to the HRI per ton of waste burned, Q_f, is computed using user entries from Screen 05. Using the operating scenario data, the total annual time required to reheat the HRI (considering no unscheduled downtime) to steady-state conditions is calculated using the assumption that a 1 ton/hour furnace or larger requires approximately 1.5 hours to bring to outlet steaming conditions following an outage lasting longer than 20 hours (refractory furnace) or 12 hours (for a water wall furnace). The time required to bring to outlet steaming conditions following a shorter outage is proportionately less and is calculated by the Model. The no downtime steady-state quantity of Btus produced by the HRI per ton of waste fired is computed as

$$(3) \quad SQ_{HRI} = (Q_f + Q_{sw})\ eff_{HRI}$$

where

Q_{sw} = heating value of the burnable waste, Btu/ton

eff_{HRI} = thermal efficiency of the HRI, %.

No downtime steady-state annual steam production (Btus) is found by multiplying SQ_{HRI} by annual steady-state trash burned. The no downtime Btu content of HRI steam production during reheating periods, RQ_{HRI}, is found by subtracting out the 2/3 power of the Btu content of auxiliary fuels and solid waste input to the HRI and then multiplying by the HRI's efficiency, i.e.,

$$(4) \quad RQ_{HRI} = ((Q_f + Q_{sw}) - (QL_f + Q_{sw}^{2/3}))\ eff_{HRI}$$

where

QL_f = the sum of the 2/3 powers of the Btu contents of auxiliary fuels (on Screen 05) input to the HRI.

The 2/3 power of the steady-state input Btu content is an estimate of heat lost during reheating. No downtime steam production during reheat periods is calculated by multiplying RQ_{HRI} by the quantity of trash burned during reheats. Finally steady-state steam production and reheat steam production are added to obtain no downtime HRI annual steam production.

e. VIRGIN FUEL OFFSET ANNUALLY BY THE HRI IN BARRELS-OF-OIL-EQUIVALENT: The turn-up Btu output of the HRI per ton of waste fired, TQ_{HRI}, is found using the same techniques described in (d). For each of SQ_{HRI}, TQ_{HRI}, and RQ_{HRI}, the energy in Btus that must be input to a fossil fuel boiler (to which the HRI is being compared) in order to produce an equivalent quantity of steam is computed by dividing by the boiler's efficiency, i.e., for the steady-state condition,

$$(5) \quad f_{stme} = SQ_{HRI} / eff_b$$

The quantity of Btus offset per ton fired is found by subtracting the Btu content of co-fired virgin fuels and electricity from the above. Again, for the steady-state condition,

$$(6) \quad f_o = f_{stme} - Q_v - f_k$$

where

Q_v = Btu content of virgin fuels

f_k = Btu content of electricity.

The total annual quantity of Btus of virgin fuel offset is found by multiplying SQ_{HRI}, TQ_{HRI}, and RQ_{HRI} by the tons of trash burned during steady-state, turn-up, and reheat conditions respectively and then adding. This figure is divided by the conversion factor 5.8 x 10^6 to obtain the quantity in barrels-of-oil-equivalent.

f. LANDFILL SPACE CONSERVED ANNUALLY BY THE HRI IN TONS: The total annual waste landfill disposal requirement (tons) assuming no HRI is computed as

(7) $TW = W_f \cdot BD \cdot BT \cdot 52 / (1 - NB)$

where

W_f = HRI combustion rate, tons/hour

BD = number of firing days per week

BT = daily burn time

NB = tons of nonburnable waste per ton of waste.

The annual quantity of nonburnable waste that must be sent to the landfill is

(8) $T_{nb} = TW \cdot NB$

The annual quantity of ash sent to the landfill is

(9) $T_{ash} = T_{burn} \cdot A$

where

T_{burn} = actual annual trash burned (found by subtracting annual tons lost from planned tons burned)

A = ash per ton of waste burned.

The annual quantity of burnable waste sent to the landfill during scheduled downtime is

(10) $T_{sched} = (52 - B_{weeks}) \cdot BD \cdot BT \cdot W_f$

where

B_{weeks} = planned annual operating weeks.

Finally, the total annual landfill space conserved in tons is given as

(11) $LSC = TW - (T_{nb} + T_{ash} + T_{lost} + T_{sched})$

where

T_{lost} = annual burnable tons lost due to unscheduled downtime.

g. COST OF USING A BOILER TO PRODUCE THE ANNUAL NO-DOWNTIME QUANTITY OF STEAM PRODUCED BY THE HRI AND LANDFILLING ALL WASTE: The annual cost of using a boiler to produce the annual no-downtime quantity of steam produced by the HRI is computed as

(12) $C_{boil} = CSP_{inf} \cdot NSP_{HRI}$

where

CSP_{inf} = *inflated per-MBtu cost of boiler* steam production

NSP_{HRI} = no downtime quantity of MBtus produced annually by the HRI

and the derivation of HRI annual steam production (no downtime) was given in the paragraphs on MBtus Produced Annually by the HRI (considering no downtime).

The annual cost of landfilling all waste is

(13) $C_{fill} = TW \cdot CWD_{inf}$

where

TW = total annual waste landfill disposal requirement

CWD_{inf} = inflated per-ton cost of landfill disposal.

The cost of using a boiler to produce the annual no downtime quantity of steam produced by the HRI and landfilling all waste is then

$$(14)\quad C_{no\ HRI} = C_{boil} + C_{fill}$$

h. INFLATED TOTAL CAPITAL COST OF THE HRI: This figure is simply the sum of the inflated costs of Equipment, Support Facilities, and Construction and Setup or the figure (inflated) entered by the user for Total Capital Cost.

i. UNIFORM ANNUAL COST OF THE HRI: Incorporated in this figure are the costs of consumables (electricity, auxiliary fuels, water, and chemicals), repair parts, sewer, insurance, pest control, labor, project lead time costs and expected modifications (costs annualized over the HRI's economic life using user-entered discount rate factors), other (entered on Screen 07 and annualized if onetime), residue disposal (nonburnable, scheduled downtime, and ash), downtime, and reheating following scheduled and unscheduled outages. The costs of electricity, auxiliary fuels, residue disposal, and possibly (depending upon how the user enters them) makeup water and chemicals are based on HRI tons of trash burned. If the HRI possesses a turn-up capability, it is assumed that usage of electricity, auxiliary fuels, water, and chemicals is increased (for fuels, water, and chemicals by a percentage equivalent to the turn-up capability; for electricity 1/3 of this rate) during turn-up periods and these additional costs are included. The cost of corrective maintenance labor is based on the number of hours of system downtime due to failure. The annual cost of HRI downtime is computed using the formula

$$(15)\quad C_{DT} = (C_{no\ HRI} - C_{no\ DT}) / (OP \cdot W_f) \cdot T_{lost}$$

where

$C_{no\ HRI}$ = annual cost of using a boiler and landfilling all waste

$C_{no\ DT}$ = no downtime cost of the HRI (computed in (j.))

OP = HRI planned annual operating hours

W_f = HRI combustion rate, tons/hour

T_{lost} = total annual tons lost due to unscheduled downtime.

If this figure is negative, the cost of downtime is taken as zero.

j. ANNUAL NO-DOWNTIME COST OF THE HRI: Incorporated in this figure are the costs of consumables (electricity, auxiliary fuels, water, and chemicals), repair parts, sewer, insurance, pest control, labor, project lead time costs and expected modifications (costs annualized over the HRI's economic life using user-entered discount rate factors), other (entered on Screen 07 and annualized if onetime), residue disposal (nonburnable, scheduled downtime, and ash), and reheating following scheduled outages. The costs of electricity, auxiliary fuels, residue disposal, makeup water, and chemicals are based on no HRI downtime. The cost of corrective maintenance labor is zero. The cost of repair parts is taken as 20 percent of the figure entered on Screen 06 (20 percent of the repair parts cost entered is assumed to be for preventive maintenance actions, 80 percent for corrective maintenance actions).

k. DISCOUNTED LIFE CYCLE COST OF USING A BOILER TO PRODUCE THE LIFE CYCLE NO-DOWNTIME QUANTITY OF STEAM PRODUCED BY THE HRI AND LANDFILLING ALL WASTE: Figures for the annual cost of an equivalent boiler and the annual cost of landfilling all waste, derived in (g.), are discounted over the HRI's economic life using user-entered discount rate factors (or the factors for the user-entered differential inflation rates for energy and landfill) and then added to give this item of the Report.

1. DISCOUNTED LIFE CYCLE COST OF THE HRI: Incorporated in this figure are the costs of labor, water, chemicals, repair parts, sewer, insurance, pest control, electricity, auxiliary fuels, residue disposal (nonburnable, scheduled downtime, and ash), project lead time costs (equipment, support facilities, construction and setup, and architect and engineer services), expected modifications, other, downtime and reheating following scheduled and unscheduled outages. User-entered discount rate factors are applied (over the HRI economic life) to the costs for labor, virgin-fuel-offsetting auxiliary fuels, water, chemicals, repair parts, sewer, insurance, pest control, project lead time, and expected modifications. If differential inflation rates are entered for energy and/or landfill, discount factors appropriate to these rates are applied to the costs for electricity, virgin fuels, residue disposal, other (energy and landfill annual or one-time costs), and reheating. Otherwise, user-entered discount rate factors are applied to these costs. As for the cost of HRI downtime, the following procedure is used to discount the annual cost of downtime, derived in (i.). If differential inflation rates for energy and/or landfill are not entered, user-entered discount rate factors are applied. If such rates are entered, the cost of downtime is split into the two quantities

$$C_{boil} / C_{no\ HRI} \cdot C_{DT} \text{ and } C_{fill} / C_{no\ HRI} \cdot C_{DT}$$

where

$C_{no\ HRI}$ = annual cost assuming no HRI (= $C_{boil} + C_{fill}$)

C_{fill} = annual cost of landfilling all waste

C_{boil} = annual cost of an equivalent boiler

C_{DT} = annual cost of HRI downtime.

Energy discount factors are then applied to the first quantity and landfill discount factors are applied to the second.

m. DISCOUNTED LIFE CYCLE COST OF AUXILIARY FUELS USED BY THE HRI: Using the figure obtained for the number of HRI hours spent firing at the turn-up rate (may be 0), the quantity of normal-rate and turn-up tons fired, T_{norm} and T_{tu}, are determined. The normal-rate per-ton costs of offsetting fuels, C_{of}, and virgin fuels, C_{vf}, are determined. The discounted life cycle cost of fuels is calculated as

$$(16)\quad LCF_{tot} = (C_{of}\ (T_{norm} + T_{tu}\ (1 + r_{tu}/100))) \cdot (b_{lead + life} - b_{lead}) + (C_{vf}\ (T_{norm} + T_{tu}\ (1 + r_{tu}/100))) \cdot (e_{lead + life} - e_{lead})$$

where

r_{tu} = turn-up capability, %

b_i = user-entered discount factor for year i

e_i = energy differential inflation rate factor for year i.

n. DISCOUNTED LIFE CYCLE COST OF NONCOMBUSTIBLE WASTE, ASH, AND SCHEDULED DOWNTIME WASTE DISPOSAL: The annual cost of nonburnable waste disposal is found using

$$(17)\quad C_{nb} = W_f \cdot BD \cdot BT \cdot 52\ (1\ /\ (1 - NB) - 1)\ CT_{nb}$$

where

W_f = HRI combustion rate, tons/hour

BD = number of firing days per week

BT = daily burn time

NB = tons of nonburnable waste per ton of waste

CT_{nb} = inflated per-ton cost of nonburnable waste disposal (Screen 06).

The annual cost of ash disposal is found using

$$(18) \quad C_{ash} = A \cdot T_{burn} \cdot CT_{ash}$$

where

A = ash per ton of waste burned

T_{burn} = actual annual trash burned

CT_{ash} = inflated per-ton cost of ash disposal (Screen 06).

The annual cost of disposing burnable waste not burned due to scheduled downtime is found using

$$(19) \quad C_{sd} = (52 - B_{weeks}) \cdot BD \cdot BT \cdot W_f \cdot CWD_{inf}$$

where

B_{weeks} = planned annual operating weeks

CWD_{inf} = inflated per-ton cost of waste (typically generated at the site) disposal.

The discounted life cycle cost of noncombustible waste, ash, and scheduled downtime waste disposal is

$$(20) \quad LCC_{disp} = (C_{nb} + C_{ash} + C_{sd}) (I_{lead + life} - I_{lead})$$

where

l_i = landfill differential inflation rate factor for year i.

o. DISCOUNTED LIFE CYCLE COST OF HRI DOWNTIME: The derivation of this figure of merit is given in (1.).

p. DISCOUNTED LIFE CYCLE COST OF THE HRI PER TON OF WASTE FIRED: This figure is computed as

$$(21) \quad LCCT = LCC_{HRI} \,/\, (T_{burn} \cdot EL)$$

where

LCC_{HRI} = discounted life cycle cost of the HRI (derivation given in (1.))

T_{burn} = actual annual trash burned

EL = HRI economic life (Screen 01).

q. DISCOUNTED LIFE CYCLE SAVINGS OF THE HRI PER TON OF WASTE FIRED: This figure is computed as

$$(22) \quad LCST = LCS_{HRI} \,/\, (T_{burn} \cdot EL)$$

where

LCS_{HRI} = HRI discounted life cycle savings (derivation to be given in (t.)).

r. DISCOUNTED LIFE COST OF THE HRI PER MBTU PRODUCED: Steady-state, turn-up, and reheat Btu outputs of the HRI per ton of waste fired, SQ_{HRI}, TQ_{HRI}, and RQ_{HRI} are found as in (d.). The quantity of trash burned during steady-state conditions is

$$(23) \quad T_{ss} = (UP - t_{tu} - t_{rh})\, W_f$$

where

UP = total annual actual operating hours

t_{tu} = time spent firing at the turn-up rate

t_{rh} = time spent for reheating.

The quantity of trash burned during turn-up periods is

(24) $T_{tu} = W_{tu} \cdot t_{tu}$

where

W_{tu} = turn-up rate.

The quantity of trash burned during reheats is

(25) $T_{rh} = t_{rh} \cdot W_f$.

HRI life cycle steam produced (MBtus) is

(26) $LC_{st} = (SQ_{HRI} \cdot T_{ss} + TQ_{HRI} \cdot T_{tu} + RQ_{HRI} \cdot T_{rh}) \cdot EL \cdot 10^{-6}$

where

EL = HRI economic life.

Finally, the discounted life cycle cost of the HRI per MBtu produced is LCC_{HRI} / LC_{st}.

s. DISCOUNTED LIFE CYCLE SAVINGS OF THE HRI PER MBTU PRODUCED: This figure is computed as

(27) $LCSE = LCS_{HRI} / LC_{st}$

where

LCS_{HRI} = HRI discounted life cycle savings (derivation to be given in (t.)).

t. DISCOUNTED LIFE CYCLE SAVINGS OF THE HRI: For each year of the HRI's economic life, the savings (or loss as the case may be) resulting from use of the HRI is determined. This figure is then discounted to the point of initial funding using the appropriate discount factor. (Since different discount factors may be required for energy and/or landfill, savings must be accounted for in the three categories Energy Savings, Landfill Savings, and Other Savings). These discounted annual savings figures are then added to determine the discounted life cycle savings of the HRI (which may be negative). Energy costs occurring annually are first identified. These include costs for electricity, virgin fuels, reheating, and any other annual energy costs entered by the user on Screen 07. Landfill costs occurring annually are identified. These include costs for noncombustible waste, scheduled downtime waste, ash disposal, and any other annual landfill costs entered on Screen 07. Other costs (those to be discounted at the user-entered discount rate) occurring annually are identified. These include costs for virgin-fuel-offsetting fuels, labor, water, chemicals, repair parts, sewer, insurance, pest control, and any other nonenergy and nonlandfill costs entered on Screen 07.

To these annual costs are added, in the appropriate category and in the appropriate project year, any one-time costs entered on Screen 07. Finally, the expected modification costs are added in the appropriate project year to the category of other costs. For each project year, energy savings is obtained as

$$C_{boil} - CE_i$$

where

C_{boil} = cost of using a boiler to produce the annual no-downtime quantity of steam produced by the HRI

CE_i = HRI total energy cost for project year i.

This figure is then discounted to the point of initial funding using the appropriate energy discount factor. For each project year, landfill savings is obtained as

$$C_{fill} - CL_i$$

where

C_{fill} = annual cost of landfilling all waste

CL_i = HRI total landfill cost for project year i.

This figure is then discounted using the appropriate landfill discount factor. For each project year, the savings (loss) for other-than-energy-and-landfill costs is obtained as

$$O - CO_i$$

where

CO_i = HRI total other cost for project year i.

This figure is then discounted using the appropriate user-entered discount rate factor.

For each project year, the figures for energy, landfill, and other savings are added to obtain a total project year savings. The sum of these total project year savings figures is the Discounted Life Cycle Savings of the HRI.

u. HRI SAVINGS-TO-INVESTMENT RATIO: The HRI SIR is the quotient of Discounted Life Cycle Savings of the HRI and the Discounted Cost of Lead Time Expenditures. Discounted Cost of Lead Time Expenditures is computed as follows. Inflated Total Capital Cost of the HRI is determined as in (h.). This figure is allocated among the years of project lead time using the user-entered percentages on Screen 01.

The inflated cost of architect and engineer services for project lead time is obtained by multiplying Inflated Total Capital Cost by the userentered percentage on Screen 03. This cost for architect and engineer services is allocated among the years of project lead time using the user-entered percentages on Screen 01. For each year of lead time, the costs for capital and architect and engineer services are added and the sum is discounted to the point of initial funding using the appropriate user-entered discount rate factor. Finally, these project lead time discounted annual costs are added to obtain the Discounted Cost of Lead Time Expenditures.

v. PAYBACK PERIOD IN YEARS: For each year of HRI economic life, the savings realized through the use of the HRI is identified as in (t.). These figures are successively added and compared with Discounted Cost of Lead Time Expenditures (u.). The project year during which cumulative savings exceeds Discounted Cost of Lead Time Expenditures is the payback period. An interpolation is performed to identify payback period to one decimal place. As project lead time is incorporated in this figure, it is called the total payback period.

SECTION 4

FLOPPY DISK MANAGEMENT

Since the data disk of the HRI Model has space enough to contain only 4 data files for HRIs, it will be necessary for the user to be able to create additional data disks. This section of the Manual presents a description of this procedure.

In addition to the HRI data files on the data disk, there are several other files that the HRI Model uses in its execution. Whenever a new data disk is to be created, these other files must be copied to the new disk. Before the copying of any files to a new disk can begin, however, the new disk must be formatted. A Master Data Disk containing all files of the data disk necessary for Model execution, a program (PIP.COM) to copy these files, and a program (COPY.COM) for formatting a new data disk is provided the user.

If the user is running the HRI Model and finds it necessary to create a new data disk, he should return to the Model's main menu. From there he should choose option 4 to stop the run. This will cause the Model to be exited and place the user in the CP/M operating system indicated by the prompt "A ." The user should then remove the Model's system disk and data disk from their respective drives and insert the Master Data Disk into Drive A and a blank disk into a second drive. The user should then depress the CTRL key and, while holding the CTRL key down, press the character "C". (This is called performing a "warm boot" of the computer using the Master Data Disk.) The user will hear a whirring sound as the computer is being booted and will then be presented with the CP/M prompt, "A ." To format the blank disk, the user should next type "COPY X:/D/V" (and then RETURN) where "X" identifies the disk drive containing the blank disk. The "D" means the disk formatted will be a data disk (it cannot be used to boot the system); the "V" tells the computer to verify the success of the format routine. To this command the computer will respond:

Softcard CP/M

16 Sector Disk Copy Program

(C) 1982 Microsoft

Insert disk into Drive X:

Press RETURN to begin

To this the user should respond by depressing the RETURN key. (The disk to be formatted is already in Drive X.) Following some clacking sounds produced as the disk is being formatted, the user will be presented with the prompt

Operation Completed

Do you wish to repeat this operation?

The user should type "N" (for "No") following which the computer will respond with the CP/M prompt, "A ."

To copy the files from the Master Data Disk onto the now-formatted blank disk, the user should type "PIP X:=A:*.*" and depress the RETURN key. (Again "X" identifies the disk drive containing the blank disk.) The user will observe on the CRT the message "COPYING-" followed by a list of the files as they are being copied. Upon completion of the copy routine, the CP/M prompt will be displayed. Two files of the Master Data Disk (COPY.COM and PIP.COM) containing the programs used to format the new data disk and copy the necessary other files should now be erased from the new data disk (this will provide more space for HRI data files). This can be accomplished by successively typing "ERA X:COPY.COM" (ERA for "Erase") and RETURN and then "ERA X:PIP.COM" and RETURN. Note: The user may view a list of the files residing on the disk in drive "X" by typing "DIR X:" (DIR for "Directory") and RETURN. The new data disk is now ready to store new HRI data files. The user can now remove the Master Data Disk from Drive A, insert the Model's system disk into Drive A, and again boot the system (this time using the system disk) by typing the character "C" while holding the CTRL key down. Typing "DBASE X:MAINMENU" and depressing the RETURN key will return the user to the HRI Model's main menu.

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ARGONNE NAT'L LAB (O. Ohlsson) Argonne, IL

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